



Conversion of existing road source data to use CNOSSOS-EU

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Summary

The Environmental Noise Directive 2002/49/EC requires the 28 Member State countries to map environmental noise following the newly adopted common noise assessment method CNOSSOS-EU. Regarding to the strategic noise mapping of road traffic noise, in the short term is was desired to enable conversion of existing datasets, associated with the current national or Interim Methods, to be utilised to help implement these new methods, instead of it being necessary to acquire new datasets. Following recent work commissioned by the European Commission, database look-up tables were developed to provide support to MS migrating from existing methods to CNOSSOS-EU, these conversion methodologies will be presented and explained. Some examples will be given on how existing data can be converted, along with any significant limitations to this approach, and methodologies for the capture of new datasets will be discussed, for situations where it is considered appropriate for the purposes of the competent authority.

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1. Introduction

In July 2014 the Member States of the European Union reached an agreement on a common method for the calculation of road traffic noise (CNOSSOS-EU), embedded in a new Annex II of Directive 2002/49/EC. This new method splits the calculation of the source sound power from the calculation of the attenuation due to sourcereceiver propagation.

The introduction of the new method means that existing data needs to be converted to the new format/new categorization, or acquired if necessary. Before entering the details of the different datasets required, it is important to recall that the methodology contains a part called "Quality framework" that requires the use of real data, not defaults, unless costs associated with the data collection are disproportionately high. It proposes that the objective for data collection of each attribute shall be "at least the accuracy corresponding to an uncertainty of $\pm 2dB(A)$ in the emission level of the source (leaving all other parameters unchanged)". Thus, it means that parameters that are not highly influential on the overall source definition, and disproportionately expensive to measure, can be approximated by defaults.

2. Overview of the method

2.1 Classification of vehicles

Road traffic noise results from the addition of the noise emission of each individual vehicle forming the traffic flow. These vehicles can be grouped in five categories with regard to their characteristics of noise emission.

- 1. Light motor vehicles
- 2. Medium heavy vehicles
- 3. Heavy vehicles
- 4. Powered two-wheelers
- 5. Open category

The classification is required to consider the different contribution that different type of vehicles have to the overall noise. Situations where it may be considered relevant to include additional vehicle categories may occur when there is an influential quantity of hybrid or electric vehicles in the fleet, or where the *A* and *B* sound power emission values for rolling and propulsion noise

are a significant variation away from the European average fleet identified within IMAGINE [3] for which the factors were developed.

2.2 Number and position of equivalent sources

For the purposes of CNOSSOS-EU these sources have been rationalised to a single point source placed 0.05m above the road surface for all vehicle classes. The traffic flow is represented by a source line. In the modelling of a road with multiple lanes, each lane should ideally be represented by a source line placed in the centre of each lane. However, for strategic noise mapping it is acceptable to model one source line in the middle of a two way road, or one source line per carriageway in the outer lane of multi-lane roads.

3. Road sound power emission

3.1 General considerations

3.1.1 Traffic flow

Traffic flow data Q_m should be expressed as a yearly average, **per hour**, per time period (dayevening-night), per vehicle class, and per source line. Average speed data v_m is a representative speed per vehicle category: in most cases the lower of the maximum legal speed for the section of road and the maximum legal speed for the vehicle category may be suitable for strategic noise mapping, if local measurement data is unavailable.

3.1.2 Individual vehicle

Equation III-2 in [2] indicates that the speed validity range is 20 < v < 130 km/h. If it is necessary and accepted to use the CNOSSOS-EU method outside this valid speed range, the following approach may be taken. For speeds lower than 20 km/h, use the 20 km/h value, for speeds higher than 130 km/h use the same equation with the actual speed.

3.2 Reference conditions

The equations and rolling and propulsion coefficients were derived under IMAGINE [13] for reference conditions, see Section III.2.2 of [2], and for a representative European average fleet:

- 187mm tyre width for Category 1,
- 19% diesel for Category 1,
- 10.5% delivery vans in Category 1,
- 4 axles for Category 3.

Whilst the reference conditions would remain the same, it may be foreseen that the average European fleet may change in the future, such as more electric vehicles, narrower tyres, fewer diesels etc which may require revised or additional *A* and *B* coefficients to be developed.

3.3 Rolling noise

3.3.1 General equation

The existing vehicle categories currently have a one-to-one relationship with the *A* and *B* values for rolling noise emission. It is considered that these are part of the CNOSSOS-EU methodology and do provide a good representation of the vehicle fleets in evidence across the EU.

3.3.2 Correction for studded tyres

The existing vehicle categories currently have a one-to-one relationship with the a_i and b_i values for rolling noise emission with studded tyres. It is considered that these are part of the CNOSSOS-EU methodology and do provide a good representation of the vehicle fleets in evidence across the EU. The JRC Reference Report indicates that the procedure to establish the correction factor for studded tyres will be explained in the "Guidelines for the competent use of CNOSSOS-EU", together with the default value to be used for P_s , the yearly average proportion of vehicles equipped with studded tyres. It should be noted that a default for P_s is not needed, as P_s is defined in formula (III-8), and is 0 in cases where no studded tyres are used.

3.3.3 Effect of air temperature on rolling noise correction

The annual average temperature within the specific time period (day, evening or night), based upon long term meteorological data should be used in Equation III-10, even if it is outside the range of 5 to 35°C indicted in Figure III.3.

3.4 Propulsion noise

3.4.1 General equation for steady state conditions

Figure III.4 in [2] only plots propulsion noise for speeds in the range 50 < v < 110 km/h. The equations behind this are valid from 20 to 130 km/h and the approach to the speed shall be as stated above. For speeds lower than 20 km/h, use the 20 km/h value, for speeds higher than 130 km/h use the same equation with the actual speed.

The existing vehicle categories currently have a one-to-one relationship with the *A* and *B* values for propulsion noise emission. It is considered that these are part of the CNOSSOS-EU methodology and do provide a good representation of the vehicle fleets in evidence across the EU.

3.5 Effect of road gradients

The gradient correction is based upon a "per lane" approach, therefore in the case of a bi-directional traffic flow the total flow should be split into two components, and half the total flow corrected for uphill travel, and half corrected for downhill travel. When the source line represents a one way flow, the gradient correction is applied without the need to split the flow.

4. Further details

4.1 Rolling noise & propulsion noise emission coefficients

The existing the A and B values for rolling noise, rolling noise with studded tyres, or propulsion noise, were derived from large databases of spectra, and come from the extensive work undertaken through the development of the Nord2000, Harmonoise and IMAGINE projects, as well as the technical work undertaken by the Member States within the CNOSSOS-EU WG/DT 2. The various factors are based upon a vehicle fleet for which the characteristics correspond to the values found for the European average as described in [13]. Despite this background, it is accepted that there may be certain situations where project or Member State (MS) specific data may be considered relevant, such as a significant variation away from the average European fleet described in IMAGINE, in which case it is proposed that where necessary an additional vehicle category is defined, which references additional values added to the emission coefficients data table. To establish a new vehicle category the following information would be required:

- Category ID number (5 or above)
- Description
- Rolling noise active or inactive
- Propulsion noise active or inactive
- Studded tyres used or not used
- A and B coefficients if studded tyres are calculated
- K surface generic coefficient K per octave to calculate the effect of air temperature on rolling noise correction
- Gradient calculation
- Emission coefficients
 - \circ coefficients $A_{R,i,m}$ and $B_{R,i,m}$ for rolling noise
 - coefficients $A_{P,i,m}$ and $B_{P,i,m}$ for propulsion noise
- Speed variations

• Coefficients $C_{r,k}$ and $C_{p,k}$ for acceleration and deceleration effect per junction type

Where appropriate it may be possible to use values from existing definitions.

4.2 Effect of the acceleration and deceleration of vehicles

For the purpose of strategic noise mapping the correction may be set to zero. There may be specific local situations where there is a desire to include the effect of acceleration and deceleration near junctions. For this purpose the CNOSSOS-EU methodology retains the ability to include specific corrections if necessary.

4.3 Effect of the type of road surface

4.3.1 General principles

CNOSSOS-EU road calculation model The assumes a virtual reference road surface, consisting of an average of dense asphalt concrete 0/11 and stone mastic asphalt 0/11, between 2 and 7 years old and in a representative maintenance condition. The $\Delta L_{\text{WR,road,i,m}}$ correction coefficient accounts for the effect on rolling noise of a road surface with different acoustic properties from the virtual reference surface. It includes both the effect on propagation and on generation. Road surface coefficients $\alpha_{i,m}$ and β_m are required for the calculation of the correction factors. $\alpha_{i,m}$ is the spectral correction in dB at reference speed v_{ref} for category m (1, 2 or 3) and spectral band i (octave band from 125 to 4000 Hz). $B_{\rm m}$ is the speed effect on rolling noise reduction. Although this coefficient is in principle frequency-dependent, no spectral data are available in the literature and a constant value is assumed in this method. In the case of a porous road surface the $\alpha_{i,m}$ coefficient will decrease the propulsion noise, but dense surfaces will not increase it.

4.3.2 Age effect on road surface noise properties

The noise characteristics of road surfaces vary with age and the level of maintenance, with a tendency to become louder over time. In this method the road surface parameters are derived to be representative for the acoustic performance of the road surface type averaged over its representative lifetime and assuming proper maintenance.

4.3.3 Further details

The road surfaces look-up table in the first version of the CNOSSOS-EU database contains the 14 road surface coefficients $\alpha_{i,m}$ and β_m from the current Dutch road traffic calculation method.

These provide a range of road surfaces considered across Europe for the purpose of strategic noise mapping, from quiet road surfaces, through standard asphalt to concrete and cobbles.

Member States which require a more specific input data tailored to road surface types in use in a specific project area may establish additional entries in the road surface database table based upon measurement information.

5. Migrating from existing national methods to CNOSSOS-EU

5.1 General approach

In order to enable data, and knowledge, relevant to existing national methods to be applied to the CNOSSOS-EU approach, it is necessary to identify how national method categories of vehicles and road surfaces may be represented in CNOSSOS-EU. Preferably the MS would establish. either from records or new measurements, relevant data in the CNOSSOS-EU database format. However, as an interim approach, the closest match between a selection of national method data categories and the default data examples within "CNOSSOS-EU Road Catalogue Final – 01April2014" ("the database") [5] have been established as follows.

In several instances the national methods use calculations of overall dB(A) emission levels, often as an SPL at a reference distance from the virtual source(s) location. As CNOSSOS-EU calculates an octave band sound power level emission for road traffic sources, the translations selected to migrate national method data into the CNOSSOS-EU databases have been based around the concept of providing similar responses to changes in input data, rather than demonstrable ability to calculate the same emission level at the reference location, as this was not possible at the time. This approach should provide sufficient clarity in the context of strategic noise mapping where hot spots are to be identified, and differences between road surfaces, for example, will be similar to the existing national method.

5.2 Road parameters

The database includes the look up tables for the road traffic emission parameters in octave bands from 63 Hz to 8 kHz, where relevant, for vehicle definitions, gradient parameters, emission factors, speed parameters and road surface corrections. With the exception of the road surface corrections, it is considered that the database values are

sufficiently applicable for strategic noise mapping in the EU; however methods for defining additional rolling and propulsion noise parameters, as well as additional road surface coefficients, have been prepared alongside CNOSSOS-EU and will form part of the future guidelines.

5.3 Defining additional rolling and propulsion noise coefficients

Should it be considered necessary to develop additional A and B coefficients for rolling and propulsion noise emission, measurements of vehicle pass-bys should be undertaken in line with those reported in TNO report [7] and those taken during IMAGINE [8]. Unfortunately, at present there is no standardised approach to follow in order to derive the relevant coefficients; however an outline of the general procedure is discussed below.

Several vehicle categories could be addressed, under the three running conditions: constant speed; accelerating / decelerating; and uphill / downhill. The vehicle speed, gradient and road surface type should all be captured if they vary from the reference conditions in CNOSSOS-EU. SEL passby levels at 7.5m from the centre of the running path, and at 1.2m and 3.0m heights should be taken in third or whole octave bands. Measurements should be undertaken in line with the requirements of ISO 11819-1 [9]. Measurements should be undertaken at a range of speeds for each vehicle in the tests program. If a small number of vehicles are to be measured, it may be possible to measure the propulsion noise directly, as discussed in [13] for HGVs and powered two wheel vehicles. For acceleration coefficients measurements should be undertaken in close proximity to crossing junctions or toll stations whilst also measuring the vehicle acceleration, as discussed in [13].

The sound pressure spectra captured during the measurements are then used in a regression analysis to obtain the coefficients. The regression analysis should be undertaken at the reference speed in order to develop new A values, and then at different speeds to get the new B values. The regression analysis can be fraught with uncertainty if a large sample set is not available, and it may be worth assuming that above 1000 Hz the noise level is likely to be dominated by tyre/road noise at higher speeds, and that engine noise may be ignored for light vehicles in these situations. As a first estimate it may be worthwhile to assume that the split between rolling and propulsion noise is in

the same ratio as in the default CNOSSOS-EU database, provided that the appropriate asphalt type is provisionally used in the formula to help avoid the new values being a combination of vehicle and asphalt type changes.

Finally the results of the analysis should be converted from sound pressure to sound power levels, taking into consideration the source directivity and microphone positions. As good practice the derived coefficients should then be used within the CNOSSOS-EU road source calculation and cross checked back to the measurement results in order to estimate uncertainty in the derived values.

Additionally, there is also discussion and guidance on the use of vehicle pass-by measurements to derive *A* and *B* coefficients in the context of NMPB 2008[10]. Unfortunately due to differences in approach between NMPB 2008 and CNOSSOS-EU, the report cannot be used as general guidance as the analysis is on the basis of a single overall value for NMPB 2008, rather than per third octave or octave band as required for CNOSSOS-EU.

5.4 Defining additional road surface coefficients

The road surface significantly affects the level of both the rolling noise and the propulsion noise; rolling noise through the excitation of the tyre structure by its surface roughness, rolling and propulsion noise through its absorption of the reflected components. Differences in pass-by noise levels of more than 15 dB can occur between rough transversely grooved concrete and 2-layer porous asphalt concrete.

Within the 5th framework program SILVIA project [11], an acoustic classification procedure for road surfaces was developed that formalizes the assessment of the road surface effect. This labelling procedure is based on the effect it has on the noise level of passing vehicles, and this effect is defined and formulated in such a way that it directly interfaces with the definition and formulation of the rolling noise and propulsion noise used in the IMAGINE model. The reduction values are defined as a difference of the emission on a certain surface and the emission of that same category on the reference surface. Since this determination should be done on trafficked roads, the SPB method should be used [9]. Although the SPB method is different from the preferred method applied in the IMAGINE study, the CPX method [12], it can be used since we only use it as

determination of a difference and not an absolute value.

One must carefully distinguish between the source effect and the propagation effect of porous surfaces. In the reduction values presented the local reflection is already included in the surface effect and shall not be included in propagation calculations.

Further information on measurement procedures is also provided in the report from the Silence project [14], whilst [15] also provides information on noise performance of aging road surfaces, and cost benefit assessment in the context of noise action plans.

6. Example migrating NMPB 96 to CNOSSOS-EU

Set out below in Figure 1 is an example of the process of developing look-up tables between parameters within an existing national method and the CNOSSOS method. This example uses the NMPB '96 method, which forms the basis of the EC recommended Interim Method. When migrating from one method to another, there are certain known limitations in addition to the variation in detailed aspects which are inherent in the new method.

In general look-up tables are presented for vehicle classes and road surface coefficients.

NMPB 96 EU Interim Vehicle class	CNOSSOS vehicle	CNOSSOS vehicle	
No of Light Vehicles	1		
50% of No. of HGVs	2		
50% of No. of HGVs	3		
NMPB 96 EU Interim Road surface	CNOSSOS road su	CNOSSOS road surface	
Rough texture paving stones (+6)	NL11		
Smooth texture paving stones (+3	NL10		
Cement concrete and corrugated	ohalt (+2) NL08		
Smooth asphalt (0dB)	NL05		
Porous surface (-1 to -3 depender	ipon speed) NL13		

Figure 1. CNOSSOS lookup table for NMPB 96 vehicle and road surface categories

In the case of the NMPB '96 example, the following should be noted during the conversion:

- 1. The lookup tables are set out in order to provide data migration from an NMPB 96 EU Interim model to a CNOSSOS-EU model;
- 2. The noise emission level of a vehicle is characterised by the maximum pass-by sound level at 7.5m from the centreline. If numerical equivalence is important to the relevant authority this would need to be investigated,

and additional input data added to CNOSSOS-EU tables;

- 3. The elementary noise source is located 0.5m above the ground. There has been no attempt to correct the emission for the difference in emission height compared to CNOSSOS-EU;
- 4. The single HGV class in NMPB 96 EU Interim has a total laden weight of at least 3500 kg, the same as the HGV classes in CNOSSOS-EU. By default it has been split 50/50 amongst the 2 HGV classes in CNOSSOS-EU, where more detailed traffic flow data is available this ratio should be adapted to each project area;
- 5. The road surface type corrections are taken from Commission recommendation 2003/613/EC which have been matched across to the Dutch road surface types of similar physical construction with similar level difference between the surfaces. If this level of detail is required additional surface types could be added;
- 6. Other emission attributes, such as speed and gradient will match directly to CNOSSOS-EU, although it is accepted they may not have the same numerical effect on the calculation.

In the present example, data is readily available for road vehicle classes, and it can be assumed that data available is sufficient to meet the quality standards required. However it may still be necessary to verify, for instance by means of a dedicated measurement campaign, that the values found in the CNOSSOS-EU database for road surface corrections meet the desired quality criteria.

7. Conclusion

The new Common Noise Assessment Method for Europe (CNOSSOS-EU) has been adopted within a revision of Annex II of Directive 2002/49/EC. To support the migration from existing national methods to the new method, as an interim solution, look-up tables have been established which help to translate existing national road traffic noise methods to CNOSSOS-EU. It is envisaged that as experience with the new method increases, and the CNOSSOS-EU databases are extended, the use of these look-up tables will reduce over time as the specific road surfaces within each country are captured in line with the CNOSSOS-EU methodology and used to extend the CNOSSOS-EU databases.

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